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EMPIRICAL OBSERVATION OF RESOLUTION DEGRADATION IN POSITRON EMISSION TOMOGRAPHS UTILIZING BLOCK DETECTORS. W.W. Moses and S.E. Derenzo. Life Science Division, Lawrence Berkeley Laboratory, University of California, Berkeley, CA.

The physical processes affecting measured spatial resolution in PET have long been quantitatively understood[1], and are attributable to four factors – detector crystal width, annihilation photon acollinearity, effective annihilation source size, and the tomographic reconstruction process. Mathematically, the reconstructed spatial resolution Γ in mm full width at half maximum (fwhm) is predicted to be:

$$\Gamma = 1.25\sqrt{(d/2)^2 + (0.0022D)^2 + s^2} \quad \text{(mm fwhm)},$$

where d is the crystal width, D is the diameter of the detector ring, s is the effective source size, the factor of 1.25 is due to reconstruction.

We empirically observe, based on published results for 7 instruments, that this formula predicts the measured reconstructed spatial resolution within 5% for PET cameras that utilize scintillation crystals that are individually coupled to photodetectors. We further observe, based on published results for 8 instruments, that this formula significantly underestimates the spatial resolution for PET cameras utilizing block detector modules. All tomographs considered used BGO scintillator and were not undersampled. The magnitude of this effect b varies between block detector designs, but b is typically 2 mm fwhm added in quadrature to the other factors, yielding a block detector formula of:

$$\Gamma = 1.25\sqrt{(d/2)^2 + (0.0022D)^2 + s^2 + b^2} \quad \text{(mm fwhm)}.$$

This degradation in block detector resolution could be caused by mispositioning of events, due to either statistical fluctuations in the photomultiplier tube signals, imperfections in the block decoding scheme, or Compton scatter within the detector. Monte Carlo simulation indicates that Compton scatter is not responsible for the degradation.

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[1] S.E. Derenzo, *Recent developments in positron emission tomography (PET) instrumentation*, SPIE Vol. 671 – Physics and Engineering of Computerized Multidimensional Imaging and Processing, pp. 232–243, 1986.